Available online at www.sciencedirect.com
SciVerse ScienceDirect
Energy Procedia 30 (2012) 1120 – 1130
Energy Procedia

SHC 2012

Tools and methods for solar design – an overview of IEA SHC Task 41, Subtask B

Miljana Horvat[a]*, Marie-Claude Dubois[b,c]

[a]Department of Architectural Science, Ryerson University,350 Victoria St., Toronto, ON, M5B 2K3, Canada
[b]Energy and Building Design, Lund University, P.O. Box 118, SE-221 00 Lund, Sweden
[c] École d'Architecture, Université Laval, 1 Côte de la Fabrique, G1R 3V6 Québec, CANADA

Abstract

This paper provides an overview of Subtask B: Tools and methods for solar design, of IEA SHC Task 41: Solar energy and architecture, 2009-2012. The focus of this Subtask was on identifying obstacles that architects are facing when implementing passive and active solar strategies in their design, especially during the early design phase (EDP) of building projects. The results of this Subtask also aim to provide strategies and resources for practitioners regarding the use of different digital tools and design methods for solar design.

Selection and/or peer-review under responsibility of PSE AG

Keywords: Task 41; Subtask B; tools and methods; solar design; early design phase (EDP); overview

1. Introduction

Previous studies done under the umbrella of the International Energy Agency identified several obstacles that hinder the application of solar energy strategies into the mainstream building practice. Traditionally, the economic issue has been dominant in this debate; however, as renewables-based energy systems costs decline, the economic issue is slowly losing its rationale. Other hindering factors include: a general lack of awareness and knowledge of the different technologies amongst building professionals, the fear or insecurity related to using new technologies and, last but not least, architectural and aesthetic considerations [1].

* Corresponding author. Tel.: + 1 416 979 5000, ext. 6512; fax: + 1 416 979 5353.
E-mail address: mhorvat@ryerson.ca

Selection and/or peer-review under responsibility of PSE AG
doi:10.1016/j.egypro.2012.11.125

In order to tackle these issues, Task 41: Solar Energy and Architecture was initiated in 2009 by the International Energy Agency, Solar Heating and Cooling Programme. The Task involved professional architects, researchers and educators from 14 countries: Australia, Austria, Belgium, Canada, Denmark, Germany, Italy, Norway, Portugal, South Korea, Singapore, Spain, Sweden and Switzerland. The ultimate goal of this three-year long project consisted of making architecture a driving force for the use of solar energy in buildings and helping instigate high-quality, inspiring architecture based on active and passive solar strategies, by identifying obstacles that architects are facing in the implementation of these strategies, proposing strategies to overcome them and improving architects' qualifications and interactions with engineers, manufacturers and clients. Out of all past and current IEA SHC Programme, this is the first one that directly addresses the architectural profession.

Subtask B of the IEA SHC Task 41, titled *Tools and methods for solar design* focused on tools and design methods currently available to architects that can assist and support design decisions in the development of solar architecture, particularly at the early design phase (EDP). The rationale for this study lays in the estimation that the majority of design decisions that can influence building's energy performance, such as form, orientation, façade design, materiality, glazing, etc., are taken at the early design phase (EDP) during which architects hold a dominant role [2,3]. Integration of both passive strategies and active solar technologies can truly be effective only if they are considered from the earliest stages of the design process and conceptual design stage. The question is, however, whether architects have the appropriate tools to deal with these issues.

2. Method

To address research objectives identified within the Subtask B, the following methodology was developed and carried out by participating task experts:

- Review and analysis of the current software landscape available for architects, with a focus on EDP;
- Identifying the obstacles architects are facing with the use of existing digital tools and methods for solar design through an online survey carried in 14 participating countries;
- Development of a handbook for architects of the most used digital tools for solar design at the EDP, that present capabilities of tools as well as case stories of successful examples of how the tools were used in real projects;
- Developing a list of needs regarding digital tools and tools' support of the conceptual stage of the solar design, based on the findings of above mentioned studies, in order to initiate communication with digital tools' developers;
- Developing a set of 3D parametric CAAD objects for photovoltaics and solar thermal components that can speed up the architectural representation at the EDP;
- Reccommending strategies for the successful use of digital tools for solar design in The Communication Guideline report, developed by Subtask C of the Task 41;
- Finally, organizing and conducting series of lectures and seminars in all participating counties in order to facilitate the dissemination of the findings of both Subtask B and the entire Task 41.

3. Results and discussion

3.1. State-of-the-art of digital tools used by architects for solar design

The first phase of the work done in Subtask B was to review and analyze the current software landscape available for architects, with a focus on EDP decisions of building projects, and to identify missing digital tools and/or missing functionalities required for encouraging and enhancing solar design of buildings and the integration of solar systems and technologies. The inventory covered a total of 56 software classified according to three categories: 23 computer-aided architectural design (CAAD) tools, 13 visualization tools and 20 simulation tools [4,5]. CAAD software included BIM applications, which are a model-based technology linked to a database of project information [6]. The selection of digital tools included in the study was made jointly by IEA Task 41 experts: architects – practitioners active in European offices, engineers, consultants, researchers and university professors involved in IEA Task 41. The tools included in the inventory are:

CAAD tools: Allplan, ArchiCAD, AutoCAD, Blender, Bricscad, Caddie, CATIA, CINEMA 4D, DDS-CAD, Digital Project, form•Z, Google SketchUp, Houdini, IntelliPlus Architecturals, Lightworks, Maya, MicroStation, Revit Architecture, Rhinoceros 3D, SolidWorks, Spirit, Vectorworks, 3ds Max;

Visualization tools: Artlantis, Flamingo, Kerkythea, LightWave, LuxRender, Maxwell Render, Mental Ray, POV-Ray, RenderMan, RenderWorks, RenderZone, V-Ray and YafaRay;

Simulation tools: bSol, DAYSIM, DesignBuilder, Design Performance Viewer (DPV), Ecotect, Energy Design Guide II (EDG II), EliteCAD, BKI ENERGIEplaner, eQUEST, Green Building Studio, IDA ICE, IES VE, LESOSAI, Polysun, PVsyst, PV*SOL, Radiance, RETScreen, T*Sol and VisualDOE.

The inventory of digital tools revealed:

- Lack of advanced solar tools supporting EDP work. Few software packages allow evaluating EDP decisions in relation to solar aspects. The EDP is a highly intuitive, iterative process, which requires changes on the building overall volume, geometry, orientation, etc. An appropriate EDP tool should allow changes on these parameters with a mouse click and the architect should have direct, explicit feedbacks related to solar aspects including passive solar gains, daylight utilization and active solar systems performance. Since, in theory, BIM-applications are created to support the whole design process, they offer the greatest potential to optimize the utilization of passive and active systems, as well as their architectural integration. However, BIM-software are not actually suited for EDP work.
- Systemic specialization of available software. Many software are specialized in one type of system (for example PV or ST). Since the goal of high quality solar architecture is to achieve a good balance of passive and active solar utilization (including daylight utilization) by an adequate design of the building envelope, this is a major hinder.
- Lack of clear numerical feedback yielding informed decisions. Solar functions are popular features in software. Generally, this feature investigates and shows the impact of sunlight and shadows on the project. However, an iterative, numeric, and direct feedback showing quantities of solar energy incident on the building is rarely available. Also, most programs only show solar radiation incident on the building rather than solar gains through windows or the amount of natural light usable inside the building.
- Lack of clear indication about physically based models in rendering options. In many CAAD and visualization software, rendering is based on “cosmetic” algorithms rather than physical laws. This may not only yield errors in interpretation from the part of the architect, it does not support development of real solar design as part of an integrated design process. The programs should at least state clearly whether the algorithms are based on physical laws of illumination or not.
- Lack of CAAD tools supporting architectural integration and sizing of active solar systems. Active solar systems sizing is mostly supported by specialized simulation software, which generally offer simplistic and limited 3D interface. To achieve an architectural integration of PV or ST to the building envelope, architects need to “see” and customize the active solar components directly in their building model.

3.2. International survey of architects regarding the use of digital tools for solar design

The second phase of the project aimed to learn from users, i.e. architects, about their satisfaction with currently available tools and methods for solar design, as well as to identify obstacles that they are facing especially during the EDP. An international survey was carried out in 14 participating countries during 2010. The survey was designed by the international team of experts involved in Task 41 and then programmed into an online survey creator. One national coordinator involved in Task 41in each participating country was responsible for distributing the survey. The coordinators used a variety of methods to reach practitioners: by publishing links for surveys through national associations of architects, through professional newsletters and magazines, through databases of professionals registered in national associations, etc. Of 627 responses received, only 350 fully completed responses were considered in the analysis [7-12].

The international survey responses indicated that the majority of respondents worked for small or medium sized firms (1-10 employees), mostly active nationally, with residential buildings being the most common type of project they were involved with. Sixty-seven percent (67%) of respondents indicated that they used a 'Conventional project delivery method', with 'Design-Build contracts' and 'Construction Management' being the second most common methods used. The majority of respondents were males (66%), born between 1960 and 1979, with more than 10 years of experience.

Although majority of respondents (82%) stated that the solar energy aspects were important in their current architectural practice, the dominant strategies actually utilized turned out to be mostly passive: 74% for 'Daylight utilization' (46% 'Always' + 28% 'Often') and 57% for 'Passive solar for heating' (32% 'Always' + 25% 'Often'). Active solar technologies were reported to be considerably less utilized (Fig.1).

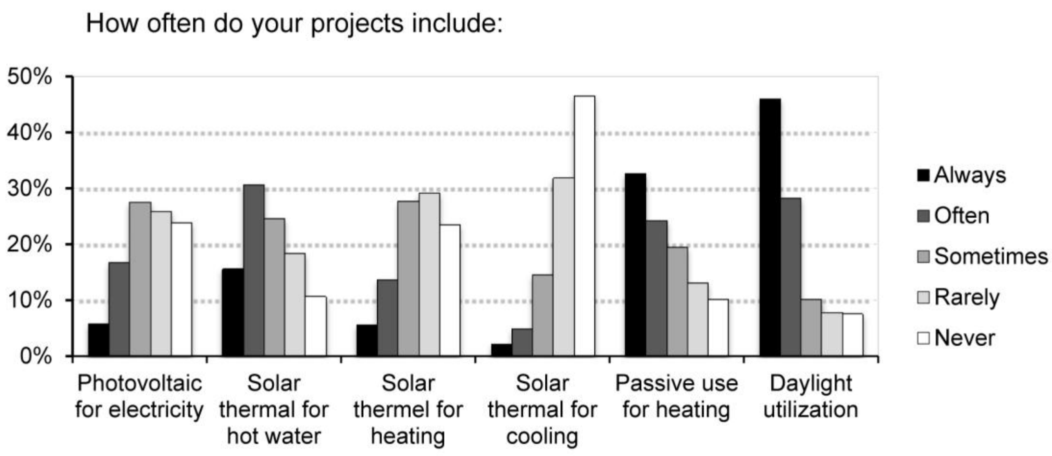

Fig. 1. Distribution of answers for question about the use of solar energy strategies and systems, for all countries (n=342)

Sixty-nine percent (69%) of the respondents stated that solar energy technologies were first considered in the conceptual phase, underlining the need for well-developed conceptual design tools. Most respondents said they base their design processes upon experiences, interaction with the project owner and by collaboration with others. Responses concerning decision making in small projects indicated that the conceptual phase was largely handled by the architect alone (53%). Specialists were more likely to be involved in later design phases, and multidisciplinary workshops played a fairly small role with a 6-10% response rate depending on design phase. In large projects, only 32% of respondents stated that this phase was handled solely by the architect. External solar energy consultants and building science specialists were relatively common in the later phases of large projects. Multidisciplinary workshops also played a more important role than in smaller projects (10-12% depending on project phase).

A question about the design stage where various software tools were used returned a number of results. The most commonly used CAAD tools were AutoCAD, Google SketchUp, Revit Architecture, ArchiCAD, Vectorworks and 3dsMax. The most common visualization tools were Artlantis, V-Ray, RenderWorks and Maxwell Render, while Ecotect, RETScreen, Radiance, Polysun, PVSol, PVsyst were the most common tools for simulation.

This study also found that the most common CAAD, visualization and simulation tools were all used in all project phases, but the relevance of different tools for different phases is well reflected in the responses. CAAD tools prioritising a simple user interface and rapid modeling (e.g. Google SketchUp) were used extensively in the EDP, while more complex tools (e.g. Revit Architecture, AutoCAD) were more common in the later project phases. A similar trend is visible concerning simulation software, with some products being preferred in the EDP (e.g. Ecotect, RETScreen) and others used more heavily in later stages (e.g. Polysun, PVSol). The most common visualization software programs were used fairly evenly across the design phases. The factor that most influenced the respondents' choice of software was a user-friendly interface (27%). The next most common factors were costs (20%), interoperability with other software (18%) and simulation capacity (13%). Quality of output (images), 3D interfaces, availability of plug-ins and availability of scripting features were considered to be less important.

Respondents reported varying degrees of satisfaction with their chosen software programs (CAAD, visualization and simulation tools) in terms of support for solar building design. For many programs, the response rate was so low that it was not possible to formulate meaningful conclusions.

The most common reported barrier regarding tools was: 'Tools are too complex' (18%, Fig. 2). Other common barriers include: 'Tools are too expensive' (14%), 'Tools are not integrated in CAAD software' (12%) and 'Tools take too much time' (11%). Respondents also stated that the tools do not adequately support conceptual design (9%), that they are too systemic (8%) and that they are not integrated in normal workflow (10%). Only 2% reported to be satisfied with the existing tools.

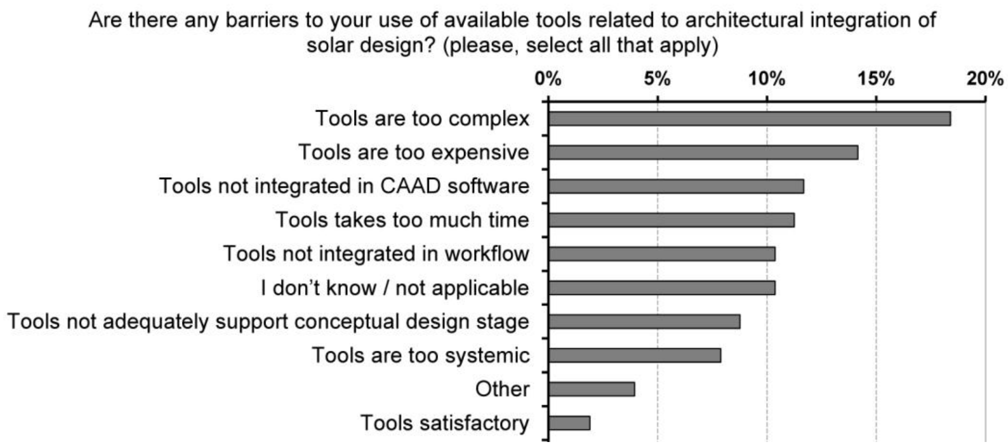

Fig. 2. Distribution of answers for question 11 about barriers related to the use of tools for the architectural integration of solar design (total number of selections is 685)

Respondents were, then, asked about the needs for improved tools in each design phase (Fig. 3). In the conceptual phase, 28% answered they would like to have improved tools for visualization, followed by preliminary sizing (20%) and tools that provide explicit feedback (18%). In the preliminary design phase, the most common request was improved tools for preliminary sizing (26%), followed by tools for key data and explicit feedback (22% and 20% respectively). For the detailed design phase, most respondents requested improved tools for key data (28%), followed by preliminary sizing (18%), explicit feedback and visualization (both 16%). The most common response for the construction drawings phase was 'I don't know/ not applicable' (29%). However, 21% also wished improved tools for key data, 16% for preliminary sizing, and 10% for tools that provide explicit feedback.

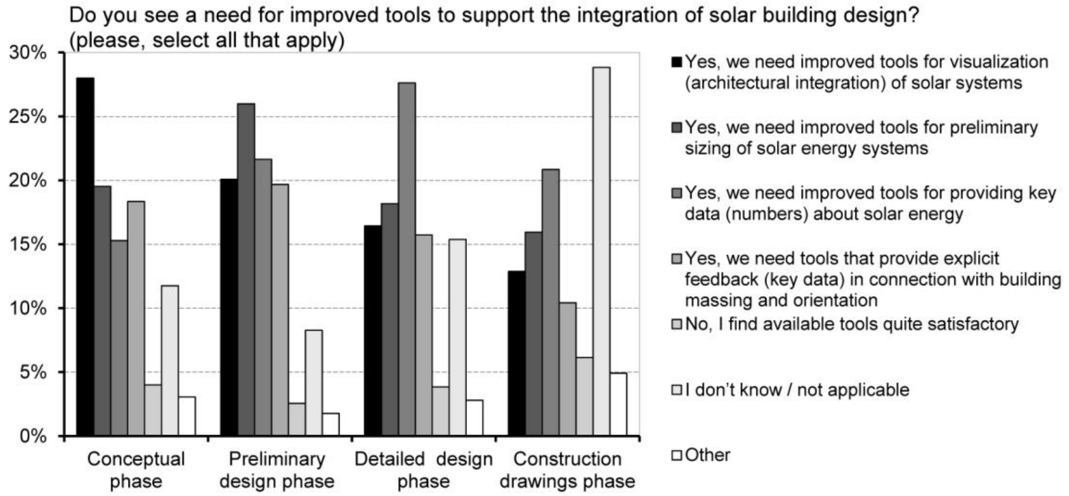

Fig. 3. Distribution of answers about needs for improved tools to support solar building design (total number of selections: 1382)

The results of this international survey on use of tools and design methods by architects for solar design at the early design phase provided valuable insight and helped in directing later stages of the Subtask B. Although the response rates were lower than hoped for, most probably because of the differences in distributing survey in different countries, which was direct consequence of available funding and resources, the findings were consistent with other similar studies covered in the literature review, presented in [7]. They confirmed the conclusion that software packages currently available to architects do not provide satisfactory support for solar design in the EDP to architects [7].

3.3. Solar design of buildings for architects: review of solar design tools

As the first two phases of the Subtask B identified shortcomings and needs, the next step was to attempt to bridge this gap. Experts agreed that a very helpful resource for architects would be a handbook or manual, which can help them in selecting appropriate design tools (digital and/or manual) at the EDP. The intention of the third report of subtask B was to raise awareness and provide guidance for architects about performance and capabilities of existing tools for solar design. The report presented 2 graphic / physical tools (i.e. solar charts and artificial sky setup) and 19 CAAD and building performance simulation (BPS) digital tools that have capability to help with solar design: from simple and qualitative to detailed and quantitative assessment of proposed design solutions. The choice of presented tools was based on [4 and 7]. The intention was not to compare and judge tools against each other, but, rather to increase overall awareness about capabilities of existing tools among architects and provide inspiration and incentive for the future choice of tool(s) [13]. The review was carried out by using the same building model, a group of buildings, as input for all tools, as far as possible.

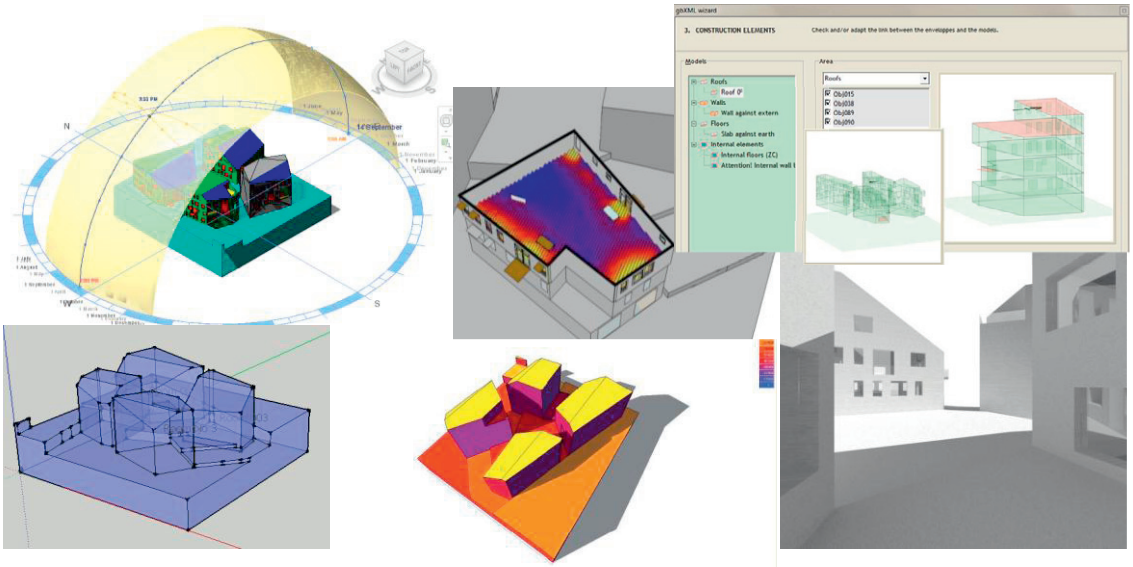

Fig. 4. Examples of output of tools presented in [13]. Top row: (a) Autodesk® Revit® Architecture, (b) Radiance, (c) Lesosai 7.1; Bottom row: (d) Google SketchUp, (e) Autodesk® Ecotect and (f) VektorWorks

In addition, this report presented three exemplary case stories that describe how different design approaches/methods and tools were used in the solar design process. In one, a client's decision to include solar and energy efficient design at the later stage of the architectural design prompted adjustments in the architects' original proposal; in another, the architectural design team worked closely from the beginning with researchers and consultants and verified each design decision through digital and physical simulations, while in the third case it was an engineering team (energy consultants) that drove the design not only to meet client's requirement (Net Zero Energy building), but to exceed them and create a Plus Energy building [13].

Finally, the process of gathering information about each tool, simulating the same building complex massing model developed for this purpose and understanding the simulation results in each particular case provided additional valuable input to participating Task 41 experts. It helped in developing and refining the list of needs of architects regarding tools for solar building design, that were originally identified through the already mentioned international survey of architects in all 14 participating countries [14].

3.4. Needs of architects regarding digital tools for solar building design

One important outcome of Task 41 and Subtask B is a reach-out to the industry and digital tool developers in the form of a letter that clearly states the perceived needs of professional architects, as they had been identified through the international survey, interviews with architects and by Task 41 experts through experience and research reviews. Some of the addressed issues include: the need for user friendly and intuitive interface, reliable import of 3D geometry, reliable and transparent default values which can be easily modified, visual (graphical) but also numerical output that is exportable to external data analysis programs, ability to assess building complexes (i.e. group of buildings), better interoperability between software packages (especially between main CAAD and simulation tools – both ways) and improved accompanying documentation that would include tutorials, manuals, but also information on algorithms used in calculations (e.g. heat transfer, solar radiation calculation, shadow calculation, etc.) [14]. The expectations are that this document will instigate a discussion, thought sharing and action in the right direction regarding improved digital tools for solar design that are intended for architects at the EDP.

3.5. Solar components 3D parametric CAAD objects

The 3D parametric CAAD objects of solar components were developed in the separate project by the Institute for Applied Sustainability to the Built Environment (ISAAC) in collaboration with IDC AG, the Swiss national Graphisoft distributor (responsible for CAD object programming), as a part of a national Swiss project: BiPV Tools, Interactive tools and instruments supporting the design of building integrated PV installations. The main goals of these new tools are: to speed up the rendering procedure when integrating PV and ST systems in building design, to facilitate and stimulate the use of BiPV (Building integrated Photovoltaic) systems by architects and designers and to improve the architectural quality of BiPV systems. The developed solar objects are compatible with both Graphisoft ArchiCAD and Autodesk AutoCAD. Available in English, French, German and Italian, the CAAD objects are accessible for free downloads from the BiPV web-site [15].

3.6. Communication guidelines

Throughout the entire Task 41, there have been close collaboration between three subtasks, either due to close connections between particular aspects of the study, or through shared resources, as majority of experts contributed to more than one subtask. Particularly valuable results of the Task 41 were instances where the outcomes of one subtask were included and built upon in another one. Such example is the Chapter 7 in The Communication Guideline, Report T.41.C.1, developed by Subtask B experts, which describes a significant role that tools for solar design can play for architects besides aiding them in solar design during the early design phase [16]. It demonstrates how proper tools can become a powerful means of communication between actors throughout the entire design and construction process: from negotiations with the client and client's advisors to dialogue with engineers, solar consultants, component manufacturers and installers at later stages.

3.7. Dissemination

Some of the final outcomes of Subtask B of the IEA Task 41 are seminars, lectures and publications intended to reach the end users: practicing architects, with hope that it would provide them with helpful resources and tools to engage and utilize both passive solar strategies and active solar technologies. In each participating country, a series of seminars, lectures and / or demonstrations have been offered since approximately mid 2010; however, the majorities are expected to be held upon the completion of the Task, when all final reports and websites are completed. Examples of reaching out to the end-users are articles in professional magazines [17], industry newsletters [18,19], continuing education sessions and seminars offered through professional associations of architects [20,21] and industry-oriented conferences [22].

4. Conclusions and outlook

This paper presents an overview of the work and results of the Subtask B: Tools and methods for solar design, which was a part of the IEA SHC Task 41: Solar Energy and Architecture. This 3-year long project gathered experts from 14 countries around the world; in Subtask B there was at least one active participant from each country. Through the extensive review, i.e. State-of-the-art report of available digital tools used in architectural practices, and international survey that aimed to hear about issues directly from users of tools, it was discovered that, although there is a great number of solar design tools available on the market today, they are not suitable for the early design phases (EDP), when key formal building decisions are taken. Currently available tools are more suitable for detail design phases; due to their complexity and detailed level of information needed for input that exceeds EDP, the current tools do not fit easily into the design workflow of are architectural offices. The work done under the Subtask B identified particular needs, such as the need for user friendly and intuitive interface, reliable import and export of 3D geometries, ability of tools to assess building complexes (i.e. group of buildings), transparencies regarding algorithms used in calculations (e.g. heat transfer, solar radiation calculation, shadow calculation, etc.) so the reliability of outputs can be verified. Identified issues are to be communicated to software tools developers' and will hopefully start discussion, thought sharing and incite action from the developers. Additionally, as this research project already identified, currently available tools have none or very limited capability to assess the building complexes. This poses considerable difficulties, as buildings ought to be looked as a part of their surroundings. Having in mind that more than 50% of the human population nowadays lives in urban areas, the need for addressing the issues related to tools in the context of solar energy and urban design is obvious. The new IEA task titled 'Solar energy and urban planning' has been recently proposed and the preparatory work is taking place at the moment.

Acknowledgements

The authors acknowledge the contributions of Miguel Pires Amado, Maria Amtmann, Émilie Bouffard, Jiangtao Du, Doris Ehrbar, Alain Filioux, Marja Edelman, Erik Eriksson, Shirley Gagnon, Susanna Geisler, Caroline Hachem, Rolf Hagen, Merete Hoff, Yixiang Huang, Jouri Kanters, Karin Kappel, Jun Tae Kim, Margarethe Korolkow, Alissa Laporte, Andreas Lechner, Marja Lundgren, Catherine Massart, Laura Maturi, Ricardo Enriquez Miranda, Kim Nagel, Mark Snow, Maria Wall, Stephen Wittkopf and Isa Zanetti. The authors also thank their respective funding agencies: Natural Resources Canada; Université Laval, Canada; Ryerson University, Canada; ENOVA SF, Ministry of Petroleum and Energy, Norway; The Swiss Federal Office of Energy; Hochschule Luzern Technik & Architektur- Kompetenzzentrum Typologie & Planung in Architektur (CCTP); SUPSI-ISAAC, Swiss BIPV competence centre; Bundesministerium für Wirtschaft und Technologie, Projektträger Jülich, Germany; Department of Innovation, Industry, Science and Research (DIISR), Austra; National Research Foundation of Korea, Green Home Technology Research Center & Zero Energy Green Village Technology Center; Swedish Energy Agency; Danish Energy Agency.

References

[1] Wall, M., Windeleff, J., & Lien, A. G. Solar Energy and Architetcure, Annex Plan. IEA-SHC Programme Task 41. 2008. Available from <http://www.iea-shc.org/publications/downloads/task41-Annex.pdf>. [24 June 2012]

[2] Potvin, A. Processus de conception énergétique intégrée : Vers une architecture durable. Congres of the AQME (Association Québécoise pour la Maîtrise de l'Énergie). 14 April 2005.

[3] Livingston, H. BIM and Sustainable Design, Part 2. Design software companies use different approaches to reach the same goal. 2007. Available from <http://www.cadalyst.com/cad/building-design/bim-and-sustainable-design-part-2-3618>. [24 June 2012]

[4] Dubois, M.-C. & Horvat, M. (editors), Report T.41.B.1 State-of-the-art of digital tools used by architects for solar design, IEA-SHC Programme Task 41: Solar Energy and Architecture. 2010. Available from: http://www.iea-shc.org/publications/downloads/IEA-T41_STB-DB1_SOA-DigitalTools.pdf>. [24 June 2012]

[5] Gagnon, S., Dubois, M.-C. & Horvat, M. (2010), High quality solar architecture: do architects have tools supporting early design phase decisions?, In Proceedings of Eurosun 2010 (CD, ISBN 978-3-901425-13-4), Graz, Austria, 28th Sep. – 1st Oct, 2010.

[6] Lee, G., Sacks, R. & Eastman, C.M., Specifying parametric building object behavior (BOB) for a building information modeling system. Automation in Construction. ISSN 0926-5805, 2006, 15(6): 758-776.

[7] Horvat, M., Dubois, M.-C., Snow, M., & Wall, M. (editors). Report T.41.B.2: International survey about digital tools used by architects for solar design. IEA-SHC Programme Task 41: Solar Energy and Architecture. Available from: < http://www.iea-shc.org/publications/downloads/International_Survey_About_Digital_Tools_Used_by_Architects_for_Solar_Design.pdf> [24 June 2012].

[9] Kanters, J. Adequacy of current design tools and methods for solar architecture – results of IEA-SHC Task 41's international survey, In Proceedings of PLEA 2011 - 27th Conference on Passive and Low Energy Buildings, Louvain-la-neuve, Belgium, 13-15 July, 2011, Vol.2, 65-70.

[10] Korolkow, M., Horvat, M., Dubois, M.-C., Kanters, J. & Bouffard. É., Tools and methods for solar building design: results of IEA Task 41 international survey, in ISES Solar World Congress 2011 Proceedings, (DVD, ISBN 978-3-9814659-0-7), Kassel, Germany, 28th Aug.- 2nd Sept, 2011.

[11] Dubois, M.-C., Horvat, M. & Kanters, J. Tools and methods used by architects for solar design: results of an international survey in 14 countries, In Proceedings of CISBAT 2011 Conference, Lausanne (Switz.), Sept. 14-16, 2011. Book of abstracts p. 178 and paper published on CD-rom.

[12] Kanters, J., Horvat, M. and M.-C. Dubois, Tools and methods used by architects for solar design, Energy and Buildings, Accepted, pending print, Reference ENB-D-12-00262R1, 2012

[13] Horvat M, Wall, M (editors). Solar Design of Buildings for Architects: Review of Solar Design Tools. Report T.41.B.3. IEA SHC Task 41, Subtask B; Available from: <http://www.iea-shc.org/publications/task.aspx?Task=41>to be published July 2012.

[14] Needs of architects regarding digital tools for solar building design. Subtask B expert group. Document T.41.B.4. IEA SHC Task 41, Subtask B; Available from: <http://www.iea-shc.org/publications/task.aspx?Task=41> to be published July 2012.

[15] Solar components 3D parametric CAAD objects. SUPSI/ISAAC, Switzerland. IEA SHC Task 41, Subtask B. Available from: <http://www.bipv.ch/index.php?option=com_content&view=article&id=338&Itemid=306&lang=en> [24 June 2012], 2011.

[16] Hagen R, Jørgensen OB (editors). Communication Guideline. Report T.41.C.1. IEA SHC Task 41, Subtask C; Available from: <http://www.iea-shc.org/publications/task.aspx?Task=41> to be published July 2012.

[17] Kanters, J., Arkitektoniska hinder för solarkitektur (Architectural barriers for solar architecture). Energi & Miljö, 2011 (May 2011).

[18] New study finds professional architects face obstacles in employing solar strategies, Building – Real Estate Development, Construction, Architecture, Daily News section, May 16th, 2011, available from: <http://www.building.ca/news/new-study-finds-professional-architects-face-obstacles-in-employing-solar-strategies/1000424097/> [24 June 2012]

[19] Why isn't solar energy's future brighter among designers? Construction Canada – The Official Publication of Construction Specification Canada, newsletter, May 18th, 2011, available from : <http://www.constructioncanada.net/newsletters/72-may-18-2011/536-why-isnt-solar-energys-future-brighter-among-designers> [24 June 2012]

[20] Horvat, M., Hansen, E.K., Architectural potential in solar design, Ontario Association of Architects annual conference 2012, Continuing education programme, available from <http://www.oaa.on.ca/news+%26+events/events/CON12_49CE> [24 June 2012].

[21] Dubois, M.C., Munari Probst, M.C. Une nouvelle ère pour le solaire en Architecture*, Ordre des architects du Québec: Congrès annuel sur l'aménagement du territoire*, Montréal, Du 31 mai au 2 juin, 2012. <http://www.oaq.com/fileadmin/fichiers/Congres_2012/programme_proof.pdf> [24 June 2012]

[22] Wall, M., Munari Probst, M.C., Roecker, C., Dubois, M-C., Horvat, M., Jørgensen O.B. and Kappel, K., Achieving solar energy in architecture – IEA SHC Task 41, In Proceedings of the International Conference on Solar Heating and Cooling for Buildings and Industry – SHC 2012. San Francisco; July 9-11, 2012.